A propos du centre ou de la direction fonctionnelle

The Inria Centre at Rennes University is one of Inria's eight centres and has more than thirty research teams. The Inria Centre is a major and recognized player in the field of digital sciences. It is at the heart of a rich R&D and innovation ecosystem: highly innovative PMEs, large industrial groups, competitiveness clusters, research and higher education players, laboratories of excellence, technological research institute, etc.

Contexte et atouts du poste

The post-doctoral fellow will be attached to the MIMETIC research team (an INRIA team common to the IRISA (Institut de Recherche en Informatique et Systèmes Aléatoires, UMR 6074) and M2S (Mouvement Sport Santé, EA 7470) laboratories) in Rennes, France. The work will be carried out in close collaboration with the Saint-Hélier teams, which are setting up rehabilitation strategies for people with disabilities, and with the Inria Rainbow team, which has proven expertise in robotic systems for disability compensation. Finally, the movement synthesis part will be treated in collaboration with the Inria camin team (montpellier) and particularly François Bailly, a specialist in the field.

Mission confiée

Background and Objectives

Issue - Loss of function of the upper extremity can occur as a result of accidents (~930 spinal cord injuries/year), strokes (350,000/year), or Duchenne muscular dystrophy (0.9% of newborns). These impairments result in, among other things, a decreased ability to support the arm and be independent. These patients require assistive and rehabilitative devices. There are passive, low-cost arm supports (e.g. KINONOA 0110, Armon products, EksoBionics) that support the weight of the upper limb through the action of anti-gravity springs. This technology can be prescribed for activities of daily living and is reimbursed by Social Security. These assistance arms are not adapted to the specific needs of individuals. Optimization of the settings of these systems will make it possible to design an aid adapted to the needs of the users. Studies have shown the interest of optimizing the settings of exoskeletons by analysis and synthesis of the movement. The analysis is extremely useful to quantify the impact of the real system from motion and effort data collected during the execution of tasks by the subject, while the synthesis allows to understand and anticipate the potential motor adaptations of the subject to the device by defining representative objectives of the motor control in a predictive simulation framework.

This type of simulation is based on musculoskeletal models of the human body that control muscle redundancy by simplified criteria of least muscle activation. For the design of an exoskeleton, it is expected that the use of the device will minimize the fatigue of our user. However, recent models propose to model the dynamics of muscle fatigue. Some works have brought their first results to deploy the motor strategies implemented to delay the onset of fatigue.

In analysis, the musculoskeletal model needs to be representative of the motor capacities of the subject studied to allow a good estimation of the impact of the system. There are therefore problems around the personalization of the model to make it faithful to the subject.

On the other hand, predictive simulations are often done with a single participant. This implies that the settings will not fit the general population and therefore the product will not be economically viable. It is necessary to have models that are representative of the target population in anthropometric and motor terms. It is possible to build representative models of the population based on anthropometric data in order to obtain adjustments to the population in the same way that we design clothing (S, M, L, etc.). The problem of a "statistically representative" model is thus emerging, allowing for the best possible coverage of the target population.

Finally, a problematic emerges on how to make the exoskeleton model interact with the musculoskeletal model within the simulation. The more the interface is faithful to reality, the more the effects of the exoskeleton are correctly reproduced within the simulation.

Objectives - The objective of the project is the study and optimization in analysis and synthesis of the impact of a passive assistance arm through a faithful representation of the subjects to be assisted and a faithful representation of the interface elements 05T. To propose a specific and generic modeling of a target population. We plan to test an arm currently developed in the laboratory on a population with a motor deficiency.
Subjects with reduced mobility of their upper limb (score<60 at Pedi-ASES14) will be recruited via the network of clinics in Rennes (Pôle Saint Hélier in particular, which has given its agreement in principle for the validation of the use case) to evaluate the impact of the system. These subjects will give rise to the development of specific and statistical models to feed the analysis and synthesis tools of the movement. The models will be obtained by carrying out a series of experimental measurements on the subjects (motion capture, medical imaging, EMG measurement, force measurement by ergometer).

OS2. Develop a model of the assistance arm cosimulated with the biomechanical model. The assistance arm will be the subject of a generic parametric model on which we will be able to carry out parametric assistance studies.

OS3. Develop and validate a clinical chart. The abacus is a diagram which gives, by simple reading, the approximate solution of a numerical problem. This tool, once designed, will allow the clinician to obtain the optimal settings of the assistance arm according to the anthropometry, the age, and the severity of the pathology thanks to the calculations carried out on the generic and specific models. Clinicians will test the settings provided by the chart with pediatric patients. It is expected that the new settings will allow users to perform daily living tasks longer and that the onset of experimental fatigue will be delayed.

**Principales activités**

**Work program**

OS1. Based on existing tools in the MimeTIC team (CusToM library) and open source tools (BiopTim), specific and generic models of the subjects to be assisted will be implemented by working to relate the experimental measurements to the motor capacities of the model. To model a patient population (generic model), anthropometric data will be used, namely height, arm size, forearm size, mass, joint effort generation capacity and age. These data will be used to generate parameters to scale musculoskeletal models representing the patient population. Pathologies will be modeled by modifying the muscle capacities of the model.

OS2. In these same tools, mechanical modeling approaches of the assistance system will be proposed to allow the interaction of this model with the above models, either in analysis or in motion synthesis. We will focus particularly on the power transmission model between the assistance arm and the human to model finely the interaction between the two, either in analysis or in motion synthesis.

OS3. 5 to 10 subjects with reduced mobility of their upper limb (score<60 at Pedi-ASES14) will be recruited via the network of clinics in Rennes (Pôle Saint Hélier in particular, which has agreed in principle to validate the use case) to evaluate the benefits of the optimal settings proposed by the abacus, compared to the classic configuration of the arm. These experiments will then allow us to determine the effectiveness of the abacus in proposing a personalized optimization of assistance arm settings. We will investigate seven tasks (school, food and play) that will be selected through collaboration with occupational therapists and clinicians.

**Compétences**

**Technical skills and level required :**

- Background in Biomechanics and/or Human-centered Robotics
- Coding in Python and C, Matlab
- Skills in Optimal control are a plus
- Experimentation skills are a plus

**Languages :**

- English

**Avantages**

- Subsidized meals
- Partial reimbursement of public transport costs
- Possibility of teleworking (90 days per year) and flexible organization of working hours
- Partial payment of insurance costs

**Rémunération**

Monthly gross salary amounting to 2 788 euros